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PRODUCTION OF SPHEROIDAL GRAPHITE CAST IRON WITH HIGHER AMOUNT OF SILICON

VÝROBA LITINY S KULIČKOVÝM GRAFITEM S VYŠŠÍM OBSAHEM KŔEMÍKU

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ABSTRACT: The paper deal with spheroidal graphite cast iron (ductile iron) with higher amount of silicon production. It was look for constructional material that would have the mechanical properties and structure homogenous into different walls castings. This material was published BJÖRKEGRN [1]. Ferritic ductile iron grade 400-15 has a tensile Rm = 400 MPa. This material has better machinability compared to conventional grades. In spite of some disadvantage e.g. lower strength yield good tensile, and the other characteristics as low costs of production or very good casting properties demand using of this sort of materials. At our Department of Mechanical Engineering at Technical university of Liberec we deal of metallurgical preparation, structure and mechanical properties ductile iron with higher amount of silicon.

ABSTRAKT: Příspěvek se zabývá výrobou litiny s kuličkovým grafitem s vyšším obsahem křemíku. Byl hledán konstrukční materiál, který by vykazoval homogenitu mechanických vlastností v různých stěnách odlitku. Tento materiál byl publikován BJÖRKEGRN [1]. Feritická litina s kuličkovým grafitem typu 400-15 s pevností Rm = 400 MPa. Tento materiál má lepší obrobitelnost než tradiční typy litiny s kuličkovým grafitem. Navzdory některých nedostatků, tj. Nižší pevnost poskytuje dobrou tažnost, nižší cenu výroby velmi dobré slévárenské vlastnosti požadované pro tyto materiály. Na katedře strojírenské technologie Technické univerzity v Liberci se zabýváme metalurgickou výrobou litiny s kuličkovým grafitem s vyšším obsahem křemíku.

KEY WORDS: spheroidal graphite cast iron with higher amount of silicon, structure, mechanical properties

KLÍČOVÁ SLOVA: litina s kuličkovým grafitem, vyšší obsah křemíku, struktura, mechanické vlastnosti

1 CHARACTERIZATION OF DUCTILE IRON

Ductile iron is produced in foundries. It is strong material with a high carbon from 3,5 to 3,9 % and content of silicon max. 2,9 %; magnesium from 0,03 to 0,06 %; sulphur max. 0,015 %; phosphorus max. 0,04 % which it can be easily melted and cast into moulds. Production of ductile cast iron belongs to quite complex problems. The major factors effecting these properties are: melting metal processing, chemical composition, solidification and cooling rate of the solid. Problem of globular graphite formation and controlling of casting structure

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and thereby their mechanical and physical properties consists in managing of basic knowledge but even all the special properties for ensure of crystallization of individual types of casting irons. Chemical composition is the primary factor affecting graphite shape control and it has a major influence on the metallic matrix. Of course for successful production of ductile iron is not enough to keep a chemical composition in frame of prescriptions. Requisite graphite shape and the metallic matrix microstructure is very much influenced by inoculation and nodulization. Very important is type nodulizer and nodulizing processes. At this time are used Compactmag or FeNiMg alloys. In the beginning of casting production is necessary to proposition temperature of melting, a type, quantity of inoculation agent addition. Noninoculated iron is almost always completely carbidic structure and graphite is nonglobular. Convenient inoculation provides sufficient nucleation centers of graphite for solidification ductile iron. In general the greater degree of nucleation in ductile cast irons the number and the smaller and move uniform in size and shope will be the graphite globular and grains of metallic matrix. There will be also less conditions for carbides to precipitation during solidification of ductile iron. The processes of inoculation and chosen type of inoculant resulting casting quality. In early times of the ductile iron production there were used inoculants take from the grey iron production, especially FeSi 75. In the time are used inoculants FeSi 75 and Superseed. But after not so satisfactory results required small amouts of additions, which ensure more uniform and smaller size of metallic matrix grants and graphite globulars. They are generally based on ferrosilicium whereas the contain one or more of the minor elements magnesium, calcium, cerium, zirkonium or other rare earth elements to stimulate their inoculating effects.

2 PRACTICAL EXPERIMENTS SPHEROIDAL GRAPHITE CAST IRON WITH HIGHER AMOUNT OF SILICON PRODUCTION

Practical experiments were made at our Department of Mechanical Engineering. The castings were produced from spheroidal graphite cast iron with higher amount of silicon. A melting unit to use is a medium frequency induction coreless furnace Indukce IO 40 with capacity of 40 kg of molten metal. All the melt were carried out under same conditions of melting, magnesium treatment (nodulizing) and inoculation. As charge material was used a pure raw iron (SORELMETAL). The iron was melted with a first batch of FeSi 75 for increase of Si amount. A sandwich method was chosen for magnesium nodulization. Chemical composition of SORELMETAL is in **Tab. 1** and nodulizer **Tab. 2**. During the application research arose the question about correct and sufficient method of inoculation. Chemical composition of inoculant is in **Tab. 3**.

Tab. 1 - Chemical composition of charge material SORELMETAL

Composition [%]						
Fe	**C**	**Si**	**Mn**	**P**	**S**	**Ni**
95,48	4,25	0,15	0,013	0,026	0,01	0,007

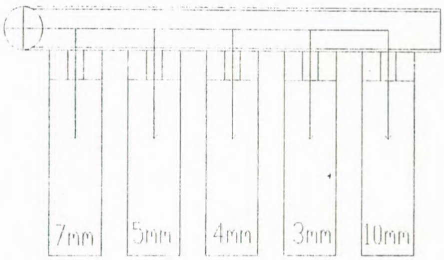
Tab. 2 - Chemical composition of nodulizer (type MgFeSi)

Composition [%]					
Fe	**Si**	**Mg**	**Ca**	**Ce**	**Al**
Rest	43,6	5,6	<0,05	<0,01	<0,02

Tab. 3 - Chemical composition of inoculants

Composition [%]					
Type of inoculant	**Si**	**Fe**	**Ca**	**Al**	**Sr**
FeSi 75	75	25	-	-	-
Superseed	75	Rest	0,1	max. 0,5	0,8

The shape of the casting was system of plates with unequal thickness. It is relatively thin-walled system of castings, sections size several plates are between 3 until 10 [mm]. These casings are determination for structure, mechanical properties (tensile and Brinell hardness) testing. The castings system shows **Fig. 1**.



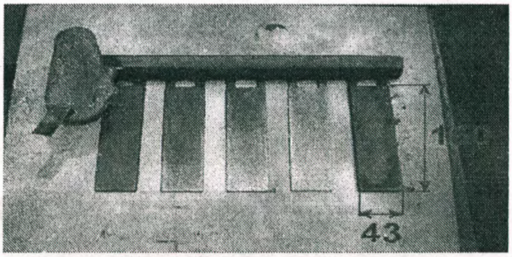


Fig. 1 - Scheme and casting of system plates

In research process were made two melts. The composition of charge is in **Tab. 4**. There is quantity of inoculants and nodulizers in **Tab. 5.** We considered two steps inoculation method. The first step was inoculation with FeSi 75 as a cover of nodulizer and the second step was effected adding into a ladle before pouring. In the **Tab. 6** is chemical composition of test melts. A mould had been made from sand bentonite mixture. Microstructures of castings were looked on microscope Neophot 21. These structures are illustrated in **Fig. 2** to **5**.

Tab. 4 - The composition of charge

Melt number	Charge [kg]			
	Sorelmetal [kg]	**Reversible material [kg]**	**FeSi 75 [kg]**	**FeMn 65 [kg]**
1	14,46	14,26	0,192	0,1
2	26,70	-	1,107	-

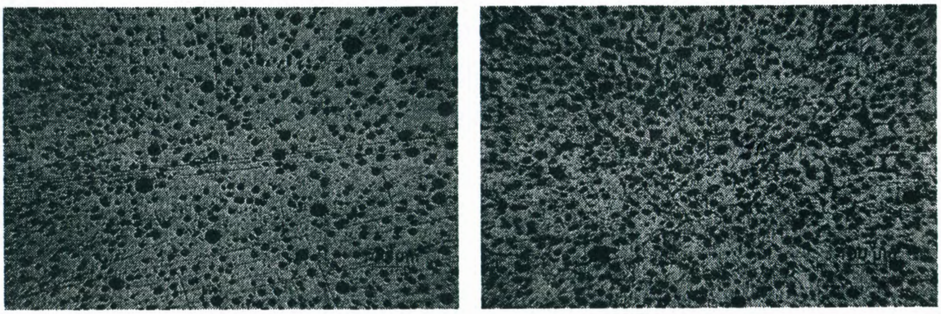
Tab. 5 - The quantity of inoculants and nodulizers

Melt number	Inoculants [kg]		Nodulizers [kg]	
	FeSi 75	**Superseed**	**Rare earth metal**	**MgFeSi**
1	0,172	0,115	0,0046	0,460
2	0,160	0,107	0,0043	0,429

Tab. 6 - Chemical composition of test melts

Melt number	Composition [%]										
	C	Si	Mg	Mn	P	S	Cr	Ni	Cu	Al	V
1	3,20	3,53	0,039	0,250	0,025	0,009	0,011	0,010	0,012	0,015	0,004
2	3,42	3,80	0,040	0,002	0,024	0,006	0,022	0,007	0,008	0,017	0,005

A strength of plates were 474 [MPa] (melt number 1) and 445 [MPa] (of melt mumber 2). An elongation was 7 [%] (melt number 1) and 6 [%] (melt number 2).



Non-each 100x Nital 100x

Fig. 2 - Structure of spheroidal graphite cast iron with higher amount of silicon 10 % VI 6 and 94 % VI 7, Fe 94 (melt number 1 – plate thickness of wall 3 mm).

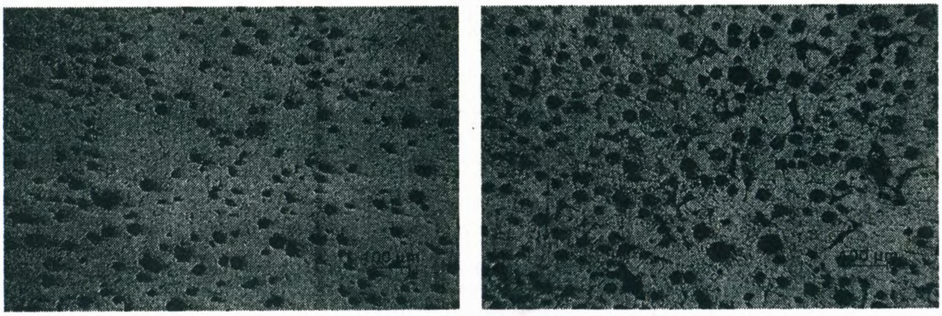


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Fig. 3 - Structure of spheroidal graphite cast iron with higher amount of silicon 100 % VI 6, Fe 94 (melt number 1 –plate thickness of wall 10 mm).

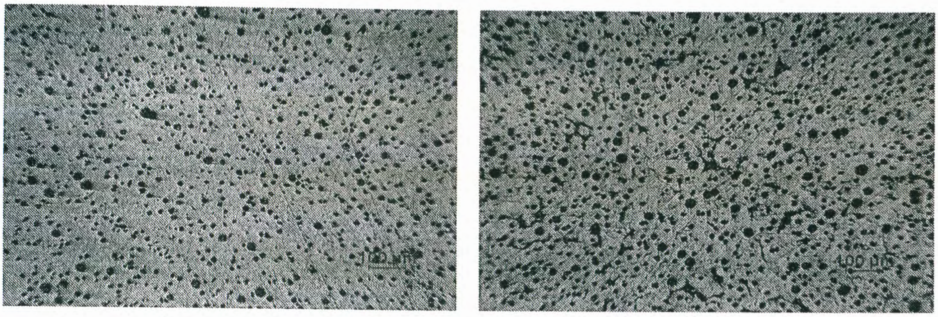

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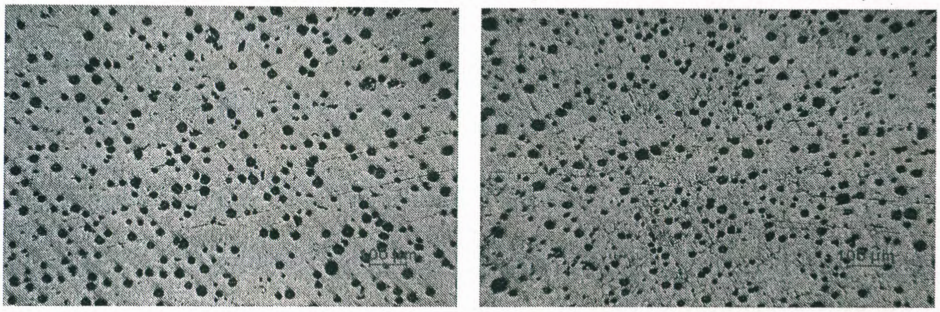
Fig. 4 - Structure of spheroidal graphite cast iron with higher amount of silicon 100 % VI 7, Fe 94 (melt number 2 – plate thickness of wall 3 mm).



Non-each 100x Nital 100x

Fig. 5 - Structure of spheroidal graphite cast iron with higher amount of silicon 100 % VI 7, Fe (melt number 2 – plate thickness of wall 10 mm).

In the scope of research work was tested Brinell hardness of casting plates. For higher speed material was used a method (HBW 5/750 kp). The results of HB for melt 1. and 2. are in the **Tab.** 7.

Tab.7 - Results of Brinell hardeness testing

Melt number	**Thickness of plate**	**Berinell hardness [HB]**							**Mean value [HB]**	**Standard deviation [HB]**
1	**3**	208	217	214	202	205	212	203	**208,7**	**5,80**
	4	212	213	211	219	221	212	218	**215,1**	**4,10**
	5	211	212	212	203	216	215	218	**212,4**	**4,90**
	8	218	219	216	215	216	210	214	**215,4**	**2,90**
	10	208	214	215	212	214	211	210	**212.0**	**2,50**
2	**3**	197	205	210	203	208	198	198	**202,7**	**5,20**
	4	197	195	204	200	208	197	193	**199,1**	**5,30**
	5	196	198	198	210	205	192	194	**199,0**	**6,40**
	8	203	197	191	202	201	204	193	**198,1**	**5,10**
	10	202	198	190	195	194	197	189	**195,0**	**4,60**

There is dependence hardness of Brinell on the thickness wall in **Fig. 6**.

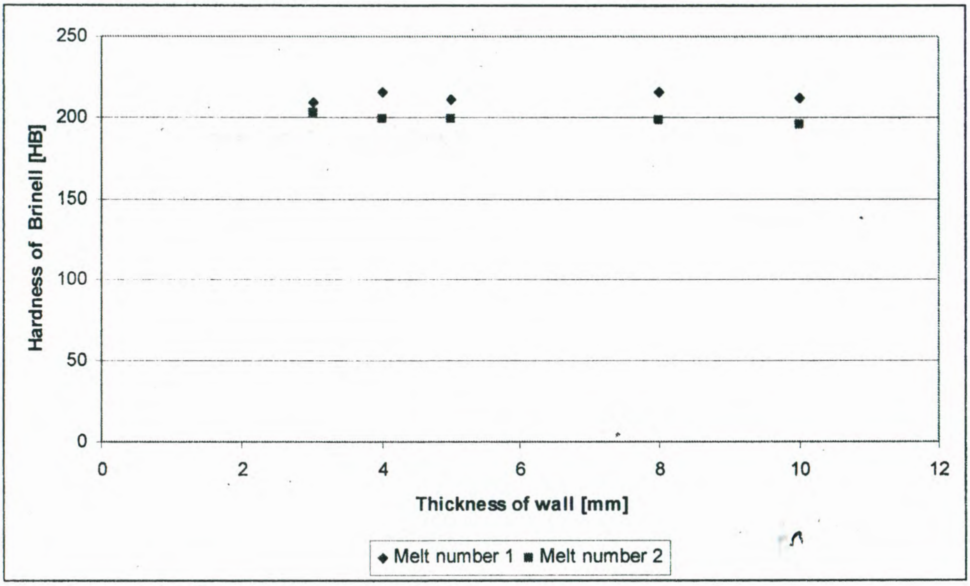


Fig. 6 - Dependence hardness of Brinell on the thickness wall

3 CONCLUSION

The paper describe problem of production ductile iron with higher amount of silicon. The material with about 3,50 to 3,85 % silicon corresponds ductile iron 450-10 i.e. Rm = 450 [MPa]. The Brinell hardness test (5mm/750 kp) is 195 to 215 [HB] for 3 to 10 [mm] thickness wall of casting. There are structures in castings 100 % globular graphite and ferrite matrix 94 to 100 %. Practical casting tests show that the material (3,5 to 3,85 % Si) does not seen to be more difficult to cast and that the level of defects is no higher, which might be feared due to the increased silicon contest.

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4 REFERENCES

[1] BJÖRKEGREN, L.E.: Ductile iron with better mechanibility compared to convecntional grades. Technical paper–Ductile iron, FOUNDRYMAN December 1998 p. 386 to 391.

[2] TVRZNÍK, P.: Metalurgické zásady výroby litiny s kuličkovým grafitem s vysokým obsahem křemíku. [Bakalářská práce]. KSP-FS, TU v Liberci 2006.

[3] JUNEK, L.: Výroba litiny s kuličkovým grafitem s vyšším obsahem Si pro automobilový průmysl. [Diplomová práce]. KSP-FS, TU v Liberci 2008.